COMPACT ELECTRONICS PLENUM

FIELD OF THE INVENTION

The present invention is generally related to heat cooling systems for portable electronic devices, and more particularly to a heat cooling system including a plenum to remove heat from ultra-compact devices including power converters, transmitters, amplifiers, and so forth.

BACKGROUND OF THE INVENTION

The miniaturization of portable consumer electronic devices is being revolutionalized by the dramatic miniaturization of electrical components, and the improved efficiencies of these electrical components. Exemplary miniaturized portable consumer electronics include power converter devices, transmitters, amplifiers, cell phones, PDA's, MP3 players, just to name a few, are made possible by improvements in technology.

While the miniaturization of components facilitates the overall reduction in device package size, a significant amount of heat is still generated by these components. It is increasingly difficult to effectively cool some of these smaller device packages as the heat generated per unit area is increasing. Power converter products, amplifiers, and communication devices, just to name a few, benefit significantly through the use of efficient cooling packages.

SUMMARY OF THE INVENTION

The present invention achieves technical advantages as a compact cooling system including a plenum formed of a thermally conductive material, the plenum including both a plurality of passageways adapted to pass air therethrough, and also having an integral receptacle adapted to wick heat from a heat generating component and transfer the heat to the passageways.

In one preferred embodiment of the present invention, the plenum is formed of a thermally conductive material, and has a base including a plurality of passageways adapted to pass air therethrough. These passageways are preferably defined by a plurality of fins extending outwardly from the base. The plenum further comprises an integral receptacle adapted to receive a heat generating component, such as a resistor, integrated circuit, or other heat generating component. The receptacle advantageously extends from the base at a location proximate, but remote from, the fins so as to thermally wick heat from the received heat generating component and transfer the heat to the fins. A fan creates air flow across the base and through the passageways proximate the fins so as to draw heat therefrom.

Advantageously, heat is efficiently transferred from the heat generating component to the plenum, and the plenum is efficiently cooled flowing air created the fan so as to provide an extremely compact design.

In one preferred embodiment of the present invention, the base has an upper surface and a lower surface, whereby the fins extend outwardly from the upper surface, and the receptacle extends outwardly from the lower surface. The base, fins and receptacle are formed as a unitary plenum, and the fins may be formed generally parallel to one another to define the plurality of adjacent

passageways. A thermally conductive lid may be coupled to the plenum to define the passageways, whereby the fins separate one passageway from another. The fins are preferably formed as a plurality of generally collinear fins in a plurality of rows. The fins of each row are separated from one another and form a brush-like arrangement so that air passing thereacross, and therebetween, can efficiency transfer heat therefrom to provide maximum cooling efficiency.

In one embodiment of the present invention, the base may also include a plurality of openings extending therethrough and communicating with the passageways. These openings are adapted to generate a venturi effect when air is communicated thereacross and through the passageways, thereby drawing heat from inside a package, through the openings, and into the passageways for dispersing thereof.

The plenum receptacle is adapted to receive the respective heat generating component in a friction fit arrangement, and extends away from the fins, and may be opposed from the fins.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective sectional view of a power converter including a plenum according to a first preferred embodiment of the present invention;

Figure 2 is a perspective view of the plenum shown in Figure 1;

Figure 3 is a perspective view of the exhaust end of the plenum of Figure 2;

Figure 4 is an elevational view of the plenum;

Figure 5 is an end view of the plenum;

Figure 6 is a top view of the plenum;

Figure 7 is a top view of the plenum with the lid removed, illustrating the brush-like cooling fins and the funneled exhaust passageway coupled to the fins;

Figure 8 is an end view of the plenum of Figure 7;

Figure 9 is a top view of the plenum;

Figure 10 is a perspective view of a second preferred embodiment of the present invention with the exhaust fan opening laterally;

Figure 11 is a perspective of the exhaust end of the plenum of Figure 10;

Figure 12 is an elevational view of the plenum;

Figure 13 is an end view of the plenum;

Figure 14 is a top view of the plenum;

Figure 15 is a perspective of the plenum of Figure 10 with the lid removed;

Figure 16 is a perspective view of the rear of the plenum illustrated in Figure 15;

Figure 17 is a top view of the plenum illustrated in Figure 15;

Figure 18 is a perspective view of a third preferred embodiment showing a plenum comprised of a electrically non-conductive material separating pair of electrically conductive heatsinks;

Figure 19 is a perspective view of the third embodiment of Figure 18 with the lid removed; and

Figure 20 is a top view of the third embodiment of Figure 19.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Figure 1, there is generally illustrated at 10 a power converter device thermally coupled to a plenum 12 according to a first preferred embodiment of the present invention. Plenum 12 is seen to have a plurality of passageways 14 each having an intake opening 15, and an opposing fan 16 at a exhaust opening 17 and thereof. Plenum 12 is also seen to include a plurality of receptacles 18 formed by integral downwardly extending members 20, each receptacle 18 seen to frictionally receive a respective heat generating electrical component 22. Plenum 12 is advantageously configured to wick heat from the heat generating members 22, and then transfer this heat to surface areas in contact with passageways 14 such that the flow of air therethrough removes heat therefrom. Device 10 is further seen to include a package housing 24 defining a chamber 26 therein housing other electrical component 28 forming a portion of the power converter housed therein.

Referring to Figure 2, there is shown a perspective view of the plenum 12 secured upon a circuit board 30, which circuit board 30 forms a part of the power converter including heat generating components 22 and components 28. As shown, the downwardly extending receptacle members 20 are adapted to straddle and frictionally receive the respective heat generating components 22.

Figure 3 depicts an end view of the plenum 12 of Figure 2, illustrating the exhaust port 17 of the plenum 12 coupled to the fan 16 drawing air into the intake openings 15 as shown. Heat generating components 22 are depicted as resistors having leads soldered to solder pads defined on circuit board 30.

Figure 4 depicts an elevational view of the plenum 12, Figure 5 depicts an

end view thereof, and Figure 6 depicts a top view of the plenum of Figure 2.

Referring now to Figure 7, there is illustrated the plenum 12 with a thermally conductive electrically non-conductive cover 34 removed therefrom. Plenum assembly 12 is seen to be comprised of a unitary thermally conductive base 38, such as comprised of aluminum oxide which advantageously is electrically non-conductive composite material but is highly thermally conductive, but may be comprised of an electrically conductive material such as copper or aluminum in some applications, such as shown in Figure 18. Base 38 has a wide planar intake area including a plurality of integral, upwardly extending, cooling fins 40 arranged in rows, as shown. This arrangement of fins 40 resembles a brush such that air drafted into passageways 14 is exposed to the large surface area of the collective fins 40, and can communicate between the passageways 14. The middle portion of the unitary member 38 is seen to funnel downwardly and inwardly to define the generally rectangular exhaust port 17 having fan 16 secured thereacross. The total area of exhaust port 17 is roughly the same surface area as the collective area of intake openings 15.

Figure 8 depicts the end view of the plenum 12, further illustrating the exhaust opening 17 facing the intake openings 15 of passageways 14 at the opposing end thereof. Advantageously, air generally flows in a common plane from the intake openings 15 to the exhaust opening 17 for exhausting by fan 16. This generally planar design provides minimal resistance for air to flow therethrough and across the brush-like fin arrangement created by fins 40.

Referring now to Figure 9, there is depicted a top view of the plenum 12 with the lid 34 removed, further depicting a linear array of openings 50 defined between each row of fins 40. Openings 50 extend through the generally planar

intake end of unitary base 38, each opening into the cavity 26 of device 10 proximate the heat generating components 22, as well as other electrical components 28 shown in Figure 1. Advantageously, as air flows across each of these openings 50, a venturi effect is created, which venturi effect draws the heating air from within cavity 26 into the passageways 14 for exhausting via fan 16.

Advantageously, the plenum 12 removes heat from the heat generating components 22 via heat conducting members 20, and also using convection due to the venturi effect created by air flowing across openings 50. This dual-mode plenum removes heat generated by components in a vary tight package, and provides cooling thereof in a very compact design.

Referring now to Figure 10, there is generally shown at 60 a plenum according to a second preferred embodiment of the present invention similar to the first embodiment depicted in Figures 1-9. In this embodiment, plenum 60 is provided with an exhaust fan 61 to exhaust heated air laterally of the plenum assembly 60 via an exhaust port 62. Intake openings 64 communicating with passageways 66 are defined at the proximal end thereof and are defined generally 90 degrees with respect to the exhaust port 62.

Figure 11 depicts an end view of the of plenum 60, whereby Figure 12 depicts an elevational view thereof. As shown in Figure 12, the downwardly extending members 20 of receptacle 18 straddle each of the respective heat generating components 22 as previously discussed in regards to plenum 12. Members 20 frictionally engage the respective heat generating component 22 to wick away the heat generated thereby. Receptacle members 20 are also integrally formed with, and form a portion of, a unitary base 68 forming plenum 60.

Referring now to Figure 12, there is depicted an elevational view of the plenum assembly 60 illustrating the lateral exhaust port 62 defined by the fan 60. Figure 13 depicts an end view of the plenum assembly 60, and Figure 14 illustrates a top view thereof.

Referring now to Figure 15, there is depicted the plenum 60 with a lid 20 removed therefrom to reveal a plurality of cooling fins 72 being integral with, and extending from, an upper surface of the base 68, similar to fins 50 of plenum 12. Fins 72 are arranged in rows to define parallel air passageways 66, and are separated therefrom to provide a brush-like arrangement. Base 68 is further seen to have a sidewall curving at a mid-section 74 to route air flowing though the passageways 66 proximate fins 72 towards the fan 16, which exhausts air therefrom laterally of the plenum 60.

Figure 16 depicts an end view of plenum 60, and Figure 17 depicts a top view thereof.

As shown in Figure 17, plenum 60 is also seen to include a plurality of openings defined through base 68 depicted at 76. Openings 76 are defined in rows, disposed between the rows of fins 72, in a collinear arrangement. Opening 76 also create a venturi effect to remove heated air from within cavity 26, thereby removing heated air created by the heat generated components 22 and other components 28 forming a portion of the portable electronic device.

The plenum according to the present invention finds particular advantages cooling heat generating components of compact devices including, but not limited to, a power converter, transmitter, amplifier, communication device, and other compact portable electronics generating excessive heat.

The present invention derives technical advantages in that the base member includes both the upwardly extending fins and the downwardly extending receptacle members 20, which are preferably opposing each other to minimize the distance therebetween and maximum cooling efficiency. This unitary base member is formed using molding techniques in one preferred embodiment. This unitary base member is also preferably comprised of an electrically non-conductive material, but may be formed of an electrically conductive material such as when used in low power applications, or other applications as desirable.

Referring now to Figure 18, there is generally shown at 80 a third preferred embodiment of the present invention wherein like numerals refer to like elements. Plenum 80 is seen to include the receptacles 20 identified as receptacle 20A and receptacle 20B, each frictionally receiving a respective heat generating component 22A and 22B.

Referring now to Figure 19, there is illustrated lid 88, comprised of an electrically non-conductive material, being removed from plenum 80. Embodiment 80 is similar to embodiment 68 of Figure 15, with the exception that the base member generally shown at 82 is comprised of a first heatsink portion 84 and a second heatsink portion 86 separated from, and interconnected by, an electrically non-conductive strip portion 88. Receptacle 20A is formed integral with the first heatsink portion 84, and the second receptacle 20B is formed integral with the second heatsink portion 86, as shown. Both the receptacles 20A and 20B, as well as heatsink portions 84 and 86, are comprised of an electrically conductive material, and separated from each other, but joined by, the electrically non-conductive strip 86.

This embodiment achieves technical advantages as each of the receptacles

and corresponding heatsink portions are formed of an electrically conductive material, as well as a thermally conductive material, yet are separated from each other by the thermally conductive, electrically non-conductive, strip 88 to provide suitable electrical isolation therebetween. Thus, the corresponding heat generating component 22A and 22B can each form a portion of two different circuits which are electrically isolated from one another, yet are advantageously thermally connected to one another to form the plenum 80. Receptacles 20A and 20B adapted to wick heat from the respective heat generating components 22A and 22B, and the cooling thereof via the plurality of fins 72, and openings 76. For instance, heat generating component 22A may form a portion of a DC/DC converter circuit, and heat generating component 22B may form a portion of a AC/DC converter circuit which are each electrically isolated from one another, but thermally coupled to each other. However, this is just but one example of an intended use for the plenum 80, and limitation to this use is not to be inferred. In another embodiment, one heatsink portion can be formed of an electrically conductive material, and the other portion formed of an electrically non-conductive material, eliminating the use of insulating strip 88.

Referring now to Figure 20, there is shown a top view of the plenum 80 illustrated in Figure 19, further illustrating the rows of openings 76 disposed between the rows of fins 72.

Though the invention has been described with respect to a specific preferred embodiment, many variations and modifications will become apparent to those skilled in the art upon reading the present application. It is therefore the intention that the appended claims be interpreted as broadly as possible in view of the prior art to include all such variations and modifications.